

# Preoperative Nutritional Status of the Surgical Patients in Jeju

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**Background:** To assess the preoperative nutritional status of patients with various disorders and to provide data for pre- and postoperative patient management plans, particularly in the elderly. There is no published information on age-matched and disease-matched preoperative nutritional/immunologic status for orthopedic patients, especially in the elderly, in Jeju.

**Methods:** In total, 331 patients with four categories of orthopedic conditions were assessed: 92 elective surgery patients, 59 arthroplasty patients, 145 patients with fractures, and 35 infection patients. Malnutrition was defined as body mass index (BMI) below 18 kg/m<sup>2</sup> of expected body weight (below 20% of normal), serum albumin/globulin ratio below 1.5 (normal range, 1.5 to 2.3), albumin level below 3.5 g/dL, total lymphocyte count below 1,500 cells/mm<sup>3</sup>, and lymphocyte/monocyte ratio below 5 versus 1.

**Results:** In 92 elective surgery patients, the average BMI was 23 kg/m<sup>2</sup>, hemoglobin was 15 g/dL, lymphocytes (2,486 cells)/monocytes (465 cells) ratio was 6.1, and the albumin (4.4 g/dL)/globulin (2.5 g/dL) ratio as a protein quotient was 1.7. Among the 59 hip and knee arthroplasty patients, the average BMI was 25 kg/m<sup>2</sup>, hemoglobin was 12 g/dL, lymphocytes (2,038 cells)/monocytes (391 cells) ratio was 6.6, and albumin (4.1 g/dL)/globulin (2.4 g/dL) ratio was 1.6. No subject showed malnutrition. Among the 145 fracture patients, the average BMI was 23 kg/m<sup>2</sup>. The hemoglobin level was 13 g/dL, monocytes (495 cells)/lymphocytes (1,905 cells) ratio was 1 versus 4.6, and albumin (4.1 d/gL)/globulin (2.5 d/gL) ratio was 1.6. However, both ratios decreased after 70 years of age. Among the 17 of 35 infection patients, albumin levels were below 3.5 g/dL, the average BMI was 22 kg/m<sup>2</sup>, lymphocytes (1,532 cells)/monocytes (545 cells) ratio was 2.4 versus 1, and albumin (3.0 g/dL)/globulin (3.3 g/dL) ratio was 0.9, while in 18 patients albumin levels were over 3.5 g/dL, the average BMI was 22 kg/m<sup>2</sup>, hemoglobin was 12 g/dL, lymphocytes (1,998 cells)/monocytes (583 cells) ratio was 3 versus 1, and albumin/globulin ratio was 1.4. Thus, in the infection group, approximately 50% of the patients showed poor nutrition and immunosuppression.

**Conclusions:** It was found that nutritional and immune condition deteriorated gradually to some degree in elderly patients over 60 years of age.

**Keywords:** Nutrition, Preoperative, Surgical conditions, Age

The nutritional and immune status of surgical patients are important in their preoperative management and post-

operative recovery. If a patient is poorly nourished, and cannot mount an effective response to an infection, the effects of any treatment are diminished. Because malnutrition adversely affects humoral and cellular immunity, and consequently impairs neutrophil chemotaxis, diminishes bacterial clearance, and depresses neutrophil bacteriocidal function, the delivery of inflammatory cells to infection foci, and serum complement components. Thus, preopera-

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tive patient nutrition conditions influence a patient's tolerance to surgical stress, postoperative physical recovery, local wound healing, and surgical infection rates.<sup>1-10)</sup>

Recent reports have highlighted malnutrition in the elderly as an important clinical and public health problem which is underdetected and undermanaged. It is known, generally, that the elderly have weakened immune conditions, which can also provoke reduced gut function and longer hospital stays.

There are several parameters in assessing nutritional status, such as Rainey-McDonald et al.'s nutritional index and others.<sup>11-13)</sup> There is a paucity of information in the Korean literature regarding the nutritional status of preoperative patients of all age groups. Again, although many elderly people have undergone total hip and knee

arthroplasty, no systematic nutritional study for them has been reported to date.<sup>7,9)</sup> Thus, the current study was designed not only to evaluate the preoperative nutritional and the immune status of all patients by decade, particularly the elderly who underwent surgeries, but also to draw surgeons' attention to this matter. For this pilot study, the Screening Tool for the Assessment of Malnutrition in Pediatrics (STAMP) scale system was not used, because we did not attempt to look for risk factors. This study seems timely, reporting for the first time overall basic data related to the preoperative nutritional and immune status of age-matched surgical patients who were not immunosuppressant users. The data obtained can be used in evaluating relationships between postoperative recovery and complications.

Cheju Halla General Hospital Dept. of Orthopedic and Traumatologic Surgery					
Patient name:	Chart No.:	Age:	Gender:		
DM	RA	Steroid user	HTN		
Dermatologic disease	Cancer drug	TNF- $\alpha$ blocker user			
	Overall Preop.	Fractures	Elective surgery	Arthroplasty	Infection
Height (cm)					
Height centile					
Weight centile					
BMI (kg/m <sup>2</sup> )					
BMI centile					
Ht. for age centile					
Singh index					
BMD					
HCT					
Hgb					
RBC					
WBC					
Lymphocytes count					
Monocyte					
Lymphocytes/monocyte ratio					
CD4/CD8					
Macrophage					
Globulin					
Total protein					
Albumin					
CRP (mg)					
BUN					
Creatinin					
Urea (mmol)					
Na					
Cl					
K					
Complication					

Definition of Malnutrition, Undernutrition (nutritional risk, assessed by STAMO score)  
 Overnutrition (determined by BMI centile)  
 Overweight:  $\geq$  91st centile, Obese:  $\geq$  98th centile

**Fig. 1.** Survey chart for preoperative age-matched nutritional status of the surgical patients.

## METHODS

This study was designed prospectively and carried out between August 2012 and June 2013. Patients undergoing elective and non-elective surgeries were included. In total, 331 patients (135 males, 186 females) underwent major orthopedic surgeries in the study period. Their ages ranged from the 2nd to the 10th decade (Fig. 1).

In the current series, patients were classified into four groups, based in their disease entities, and then were classified into two: elective and non-elective surgery groups. The non-elective group of patients underwent surgery even in cases of less favorable physical conditions because of their state of need/urgency. For the elective (92

patients) and arthroplasty (59 patients) groups, only the physically able ones (high levels of activity) were subjected to surgery, while for the non-elective surgeries, including fracture (145 patients) fixation and infection (35 patients), there was no choice due to care urgency for patient selection. Individuals receiving immunosuppressant therapy and having immunologically suppressed diseases were excluded. A survey chart is shown in Fig. 1.

This study was approved by the Institutional Review Board of the Cheju Halla General Hospital. Informed consent was obtained.

### Statistical Analyses

The SPSS ver. 17.0 (SPSS Inc., Chicago, IL, USA) was used for statistical analyses. All measurement of age-matched lymphocyte/monocyte and albumin/globulin ratios were analyzed by ratio scales, and for the comparative analysis of the four groups after calculating the average values, significance was assessed using independent sample *t*-tests and one-way analysis of variance (ANOVA). A  $p < 0.05$  was considered to indicate statistical significance (Table 1).

## RESULTS

The overall candidates were classified into 4 group, the total count was 331 patients (Table 2). The average body

**Table 1.** The Correlation between Categories and Parameters

Category	Lymphocyte/monocyte ratio	Albumin/globulin ratio
Elective	0.020	0.029
Arthroplasty	0.015	0.072
Fracture	0.003	0.002
Infection	0.190	0.276

Statistical significance was tested by one-way analysis of variance (ANOVA) among groups. *p*-values are indicated by numerals.

**Table 2.** Overall Preoperative Nutritional Status of 331 Patients

Decade	Various nutritional components														
	M	F	H	W	BMI		Hematology								
					kg/m <sup>2</sup>	Centile	Hct	Hgb	Lymphocyte	Monocyte	L/M ratio	Albumin	Globulin	A/G ratio	
2nd	5	3	161	59	21	65	41	14	2,771	648	4.9	4.3	3.0	1.4	
3rd	9	4	170	67	22	53	43	14	2,302	393	6.8	4.6	2.5	1.9	
4th	17	3	167	72	24	61	39	13	2,051	624	3.7	3.9	3.1	1.3	
5th	27	14	162	64	21	49	39	12	1,903	637	3.6	3.9	2.6	1.4	
6th	23	21	160	61	23	36	35	11	1,992	432	5.4	3.8	2.8	1.4	
7th	28	69	159	62	24	51	34	15	2,022	551	4.3	3.7	2.8	1.3	
8th	22	59	158	59	23	45	36	12	1,782	457	4.6	3.7	2.6	1.4	
9th	4	16	158	58	23	51	34	11	1,808	539	4.0	3.6	2.4	1.4	
10th & over	0	7	152	53	21	39	35	11	1,501	488	4.0	3.8	2.7	1.4	
Total	135	186	160.6±5	61.8±5	26.6±1.2	50.6±9	39.4±3	12.8±1.1	1,991.8±350	495.8±85	4.54±1	3.9±0.3	2.7±0.2	1.4±0.1	

Patients' nutritional status was defined as poor in the following conditions: (1) BMI < 18 kg/m<sup>2</sup> (optimum BMI: 20–25 kg/m<sup>2</sup>). (2) Weight < 20% of expected. (3) Serum albumin < 3.5 g/L (3.4 g/L), albumin/globulin ratio (weight ratio) below 1.7 (normal range, 1.5–2.3). (4) Total lymphocyte count < 1,500 cells/mm<sup>3</sup>. (5) Total lymphocyte/monocyte ratio below 5 vs. 1.

M: male, F: female, H: height, W: weight, BMI: body mass index, Hct: hematocrit, Hgb: hemoglobin, L/M: lymphocyte/monocyte, A/G: albumin/globulin.

**Table 3.** Preoperative Nutritional Status of 92 Patients with Elective Surgery

Decade	Various nutritional components													
	M	F	H	W	BMI		Hematology							
					kg/m <sup>2</sup>	Centile	Hct	Hgb	Lymphocyte	Monocyte	L/M ratio	Albumin	Globulin	A/G ratio
2nd	2	2	161	50	19	50	42	14	3,625	832	6	4.6	2.5	1.8
3rd	2	4	169	68	23	56	44	15	2,358	296	7.8	4.7	2.3	2.0
4th	5	1	173	82	27	86	45	14	2,663	598	4.6	4.4	2.7	1.6
5th	10	8	164	68	16	55	41	14	2,119	375	5.6	4.3	2.6	1.6
6th	2	7	158	63	25	50	41	13	2,443	288	7.1	4.6	2.6	1.7
7th	8	16	160	63	24	49	38	17	2,040	441	5.9	4.1	2.5	1.6
8th	11	13	160	59	23	43	38	19	1,998	453	5.5	4.0	2.4	1.6
9th	1	-	163	74	27	76	42	14	2,640	434	6	4.3	2.4	1.7
10th & over	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	41	51	163±4	66±9	23±3	58±13	41±2	15±1	2,486±450	465±150	6.1±0.9	4.4±0.2	2.5±0.1	1.7±0.1

Patients' nutritional status was defined as poor in the following conditions: (1) BMI < 18 kg/m<sup>2</sup> (optimum BMI: 20–25 kg/m<sup>2</sup>). (2) Weight < 20% of expected. (3) Serum albumin < 3.5 g/L (3.4 g/L), albumin/globulin ratio (weight ratio) below 1.7 (normal range, 1.5–2.3). (4) Total lymphocyte count < 1,500 cells/mm<sup>3</sup>. (5) Total lymphocyte/monocyte ratio below 5 vs. 1.

M: male, F: female, H: height, W: weight, BMI: body mass index, Hct: hematocrit, Hgb: hemoglobin, L/M: lymphocyte/monocyte, A/G: albumin/globulin.

**Table 4.** Preoperative Nutritional Status of 59 Patients with Arthroplasty

Decade	Various nutritional components													
	M	F	H	W	BMI		Hematology							
					kg/m <sup>2</sup>	Centile	Hct	Hgb	Lymphocyte	Monocyte	L/M ratio	Albumin	Globulin	A/G ratio
2nd	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3rd	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4th	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5th	1	1	166	76	27	92	46	15	1,960	710	3.9	4.4	2.7	1.6
6th	1	3	153	55	22	36	37	12	2,036	213	9	4.1	3.0	1.6
7th	3	27	156	66	27	68	37	12	2,076	340	6	4.1	3.1	1.3
8th	2	19	154	60	25	55	38	12	2,129	360	7.7	4.2	2.4	1.7
9th	1	1	152	56	24	51	36	11	1,990	334	6.6	3.8	3.0	1.2
10th & over	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	8	51	156±5	62±7	25±1	60±18	38±3	12±1	2,038±60	391±80	6.6±1	4.1±0.3	2.4±0.3	1.6±0.2

Patients' nutritional status was defined as poor in the following conditions: (1) BMI < 18 kg/m<sup>2</sup> (optimum BMI: 20–25 kg/m<sup>2</sup>). (2) Weight < 20% of expected. (3) Serum albumin < 3.5 g/L (3.4 g/L), albumin/globulin ratio (weight ratio) below 1.7 (normal range, 1.5–2.3). (4) Total lymphocyte count < 1,500 cells/mm<sup>3</sup>. (5) Total lymphocyte/monocyte ratio below 5 vs. 1.

M: male, F: female, H: height, W: weight, BMI: body mass index, Hct: hematocrit, Hgb: hemoglobin, L/M: lymphocyte/monocyte, A/G: albumin/globulin.

mass index (BMI) and hemoglobin of the 331 patients were 26.6 kg/m<sup>2</sup> and 12.8 g/dL. The average lymphocyte (1,991 cells)/monocyte (495 cells) ratio was 4.5 versus 1, and the serum albumin (3.9 g/dL)/globulin (2.7 g/dL) ratio, as the protein quotient, was 1.4 (Table 1).

#### Elective Surgery Group (92 Patients)

The average BMI and hemoglobin were 23 kg/m<sup>2</sup> and 15 g/dL. The average lymphocyte (2,486 cells)/monocyte (465 cells) ratio was 6.1, and the albumin (4.4 g/dL)/globulin (2.5 g/dL) ratio was 1.7 (Table 3). There was no subnormal value.

#### Arthroplasty Patient Group (59 Patients)

The average BMI and hemoglobin were 25 kg/m<sup>2</sup> and 12 g/dL. The average lymphocytes (2,038 cells)/monocyte (391 cells) ratio was 6.6, and the albumin (4.1 g/dL)/globulin (2.5 g/dL) ratio was 1.6. Only two subjects in their 9th decades of the 59 patients showed some decline in nutritional status (Table 4).

#### Fracture Group (145 Cases)

The average BMI and hemoglobin were 23 kg/m<sup>2</sup> and 13 g/dL. The average lymphocyte (1,905 cells)/monocyte (495 cells) ratio was 4.6, and the albumin (4.1 g/dL)/globulin (2.5 g/dL) ratio was 1.6. However, both ratios decreased

after age 70 years (Table 3). Among the 145 patients who had fracture fixation surgery, the 45 patients over the 8th decade showed gradual declines in nutritional and immune status (Table 5).

#### Infection Group (35 Patients)

Among 17 of 35 infection patients with albumin levels below 3.5 g/dL, the average BMI was 22 kg/m<sup>2</sup>, the lymphocyte (1,532 cells)/monocyte (545 cells) ratio was 2.4, and the albumin (3.0 g/dL)/globulin (3.3 g/dL) ratio was 0.9, while in 18 patients with albumin levels over 3.5 g/dL, the average BMI was 22 kg/m<sup>2</sup>, hemoglobin was 12 g/dL, the lymphocyte (1,998 cells)/monocyte (583 cells) ratio was 3, and the albumin/globulin ratio was 1.4. Thus, in the infection group, approximately 50% of the patients had poor nutrition and immunosuppression. The infection rate was higher in patients with serum albumin levels below 3.5 g/dL (Table 6).

In the infection group, there was no statistically significant ( $p > 0.05$ ) result, which may have been due to the smaller number of samples than in the other groups. However, in the other groups (arthroplasty, elective surgery, fractures), there were statistically significant differences ( $p < 0.05$ ) by decade and lymphocyte/monocyte and albumin/globulin ratios.

In summary, nutrition in the patients who under-

**Table 5.** Preoperative Nutritional Status of 145 Patients with Fracture

Decade	Various nutritional components													
	M	F	H	W	BMI		Hematology							
					kg/m <sup>2</sup>	Centile	Hct	Hgb	Lymphocyte	Monocyte	L/M ratio	Albumin	Globulin	A/G ratio
2nd	2	-	175	74	24	77	46	16	2,805	470	6.0	4.6	2.5	1.8
3rd	7	-	172	67	22	50	43	14	2,247	490	5.9	4.5	2.7	1.8
4th	9	2	171	82	27	74	43	14	1,824	429	5.2	4.2	2.4	1.7
5th	14	5	165	67	24	54	37	13	1,969	551	4.6	4.1	2.6	1.5
6th	16	9	163	64	24	38	38	12	1,937	571	4.0	4.0	2.5	1.6
7th	12	14	160	62	24	41	41	14	1,985	458	4.7	4.0	2.7	1.4
8th	6	17	155	54	22	34	34	11	1,581	483	3.5	3.7	2.5	1.4
9th	1	14	155	52	21	32	32	12	1,299	520	3.2	3.6	2.4	1.5
10th & over	-	7	152	53	21	35	35	11	1,501	488	4.0	3.8	2.7	1.4
Total	67	78	163 ± 5	64 ± 7	23 ± 1	50 ± 16	50 ± 3	13 ± 1	1,905 ± 350	495 ± 55	4.6 ± 0.7	4.1 ± 0.2	2.5 ± 0.1	1.6 ± 0.1

Patients' nutritional status was defined as poor in the following conditions: (1) BMI < 18 kg/m<sup>2</sup> (optimum BMI: 20–25 kg/m<sup>2</sup>). (2) Weight < 20% of expected. (3) Serum albumin < 3.5 g/L (3.4 g/L), albumin/globulin ratio (weight ratio) below 1.7 (normal range, 1.5–2.3). (4) Total lymphocyte count < 1,500 cells/mm<sup>3</sup>. (5) Total lymphocyte/monocyte ratio below 5 vs. 1.

M: male, F: female, H: height, W: weight, BMI: body mass index, Hct: hematocrit, Hgb: hemoglobin, L/M: lymphocyte/monocyte, A/G: albumin/globulin.

**Table 6.** Preoperative Nutritional Status of 35 Infection Patients

Decade	Various nutritional components													
	M	F	H	W	BMI		Hematology							
					kg/m <sup>2</sup>	Centile	Hct	Hgb	Lymphocyte	Monocyte	L/M ratio	Albumin	Globulin	A/G ratio
2nd	-/1	1	158/153	63/52	25/19	85/50	42/35	14/12	2,460/2,195	550/790	4.9/2.7	4.6/3.4	2.8/4.5	1.6/0.7
3rd	1/-	-	155/-	50/-	20/-	30/-	43/-	16/-	990/-	500/-	1.9/-	3.6/-	2.8/-	1.3/-
4th	2/1	-	156/171	55/70	22/23	40/45	34/36	12/12	1,780/1,940	760/710	2.3/2.7	3.9/3.3	3.4/4.0	1.2/0.8
5th	1/1	-	158/161	58/51	21/19	38/10	38/33	11/11	1,980/1,490	800/750	2.4/1.9	4.0/2.9	2.2/3.3	1.8/0.8
6th	2/2	2	158/169	56/67	22/23	30/30	29/31	10/9	2,105/1,443	740/350	2.9/4.0	3.6/3.0	2.4/3.5	1.5/1.1
7th	2/3	2	157/166	56/67	23/25	38/58	39/19	13/23	2,740/1,270	720/797	3.8/1.5	3.8/2.9	3.2/2.6	1.2/0.8
8th	1/2	5/5	165/159	62/61	22/24	46/46	38/32	12/10	1,620/1,585	476/513	3.4/3.0	3.8/2.8	2.4/3.3	1.6/0.8
9th	-/1	-/1	166/157	50/57	21/24	35/65	30/33	10/11	2,310/805	770/640	3.0/1.2	3.5/3.1	2.1/2.1	1.6/1.4
Total	8/11	10/6	159 ± 3/ 162 ± 6	57 ± 3/ 60 ± 7	22 ± 1.3/ 22 ± 2	42 ± 16/ 43 ± 17	37 ± 4/ 31 ± 5	12 ± 1.9/ 12 ± 4	1,998 ± 500/ 1,532 ± 410	583 ± 60/ 545 ± 150	3.0 ± 0.8/ 2.4 ± 0.8	3.8 ± 0.3/ 3.0 ± 0.2	2.6 ± 0.4/ 3.3 ± 0.7	1.4 ± 0.2/ 0.9 ± 0.2

Patients' nutritional status was defined as poor in the following conditions: (1) BMI < 18 kg/m<sup>2</sup> (optimum BMI: 20–25 kg/m<sup>2</sup>). (2) Weight < 20% of expected. (3) Serum albumin < 3.5 g/L (3.4 g/L), albumin/globulin ratio (weight ratio) below 1.7 (normal range, 1.5–2.3). (4) Total lymphocyte count < 1,500 cells/mm<sup>3</sup>. (5) Total lymphocyte/monocyte ratio below 5 vs. 1.

M: male, F: female, H: height, W: weight, BMI: body mass index, Hct: hematocrit, Hgb: hemoglobin, L/M: lymphocyte/monocyte, A/G: albumin/globulin.

went elective surgeries, including total joint replacements, was essentially normal, while it was poor in the non-elective surgery patients. Overall, average nutritional status in the current series was not poor even in the elderly, apart from a few exceptions.

## DISCUSSION

Malnutrition is an abnormal state that can be detected and corrected in most cases. The prevention or correction of malnutrition in orthopedic patients has a significant effect in preventing operative and postoperative complications. Numerous studies have documented the presence of protein and calorie malnutrition in hospitalized patients. To understand how malnutrition adversely affects the recovery of patients from surgery, their nutritional needs must be known.<sup>1-10</sup> Gherini et al.<sup>10</sup> reported that the incidence of moderate nutritional deficiencies in patients undergoing total hip arthroplasties was only 3%, although the incidence of malnutrition has been reported to be as high as 48% at the time of admission.<sup>13-15</sup>

A preoperative patient's nutritional condition reflects not only his/her health status, but also, indirectly, the patient's immune status. It influences the patients' tolerance to surgical stresses, postoperative physical recovery, local wound healing, and surgical wound infection rates. Humoral and cell-mediated immunities are affected ad-

versely by poor nutrition.

Immunological changes occur quickly with protein-calorie malnutrition, and can have a profound effect on complication rates. Depletion of body protein is associated with prolonged convalescence, poor healing of wounds, increased susceptibility to infection, anemia, edema, impaired gastrointestinal motility, and skeletal muscle weakness.<sup>7,9,11-17</sup>

Cell-mediated immunity is impaired in part because the number and function of lymphocytes, mainly T-cells, decreases. There is a decrease in the amount and T-cell composition of lymphoid tissue, and there is a decreased response to recall antigen skin testing.<sup>17</sup> Humoral immunity is affected similarly. Complement activity and granulocyte functions are inhibited. In children, it has been shown that there is a decrease in interferon production. Immunity is also affected by undernourishment of trace substances, such as iron, zinc, pyridoxine, vitamins B<sub>12</sub>, A, and C, and folates.

Previously, only serum proteins and total lymphocyte counts were the standard for assessing malnutrition.<sup>1,9</sup> Dreblow et al.<sup>1</sup> assessed orthopedic admissions, both trauma and elective, and noted a significant correlation between albumin levels < 3.5 g/dL and increased length of hospital stay.

In Del Savio et al.'s<sup>9</sup> preoperative nutritional study on elective total joint replacement, they used serum pro-

tein and total lymphocyte counts as markers for subclinical malnutrition. Because the half-life of albumin is 3 weeks, this test represents the best measurement of chronic malnutrition, not short-term fluctuation, as compared with other proteins with shorter half-lives.<sup>8)</sup>

Nutritional status is generally determined by the following three components: (1) anthropometric measurements, (2) measurements of serum proteins or cell type (lymphocytes), and (3) antibody reactions to certain antigens in skin testing. In diseases, albumin is decreased, while globulins are increased in compensation to maintain a normal plasma protein concentration. The protein quotient (the albumin/globulin ratio) is the weight ratio of albumin to globulin, and is normally 1.7 (range, 1.5 to 2.3). This value becomes lower in protein deficiency and abnormalities of protein intermediary metabolism. Thus, all these tests are essential to assess a patient's true physical condition. Measured data, such as BMI ( $< 18 \text{ kg/m}^2$ ), weight ( $< 20\%$  of expected normal), serum albumin level ( $< 3.5 \text{ g/dL}$ ), total lymphocyte count (TLC  $< 1,500$  cells), and the lymphocyte/monocyte ratio ( $< 5:1$ ) indicate not only individual nutritional status, but also indirectly reflect individual immune status.<sup>8-10)</sup>

In recent years, the proportion of the elderly population undergoing surgery has increased because of increased rates of arthroplasties of hips and knees and degenerative spinal diseases, and it will likely continue to rise substantially. Harris and Sledge<sup>7)</sup> reported that 21.3% of total hip replacement patients had an albumin level below 3.5 g/dL and they stayed 4.9 days longer in hospital. Thus, adverse outcomes in the postoperative period can occur at high rates. It is generally agreed that nutrition status, age, and associated co-morbidities play a major role in operative risks and prognosis. Some authors have used hematological markers, such as visceral proteins, principally albumin, TLC, and transferrin, which have been shown to be sensitive indicators of malnutrition, as useful tools in the clinical setting. The STAMP scoring system was not used in the current study, because we did not attempt to look for risk factors.

Elderly individuals are known to have poor physiological reserves and an inability to mount appropriate physiological response to surgical trauma and medications.<sup>7)</sup> Based on these facts, it is generally known that immunity in the elderly is weakened, and postoperative infection rates are generally higher than in younger patients. Thus, it is important to routinely assess the preoperative nutritional condition of all surgical patients, especially elderly individuals. As mentioned above, recent reports have highlighted malnutrition in the elderly as an impor-

tant clinical and public health problem, which is typically underdetected and undermanaged. Unfortunately, in the current series, we could not use the Rainey-McDonald et al. nutritional index, based on serum albumin and transferrin levels {formula:  $(1.2 \times \text{serum albumin}) + (0.013 \times \text{serum transferrin}) - 6.43$ } because the Korean government insurance scheme does not cover the routine examination of transferrin in all surgical patients. If the sum of this nutritional index is zero or negative, the patient is considered nutritionally depleted and is at high risk of sepsis.

It is reported that if the serum albumin level is below 3.5 g/dL or if the total lymphocyte count is below 1,500 cells/mm<sup>3</sup>, then healing may not take occur.<sup>6)</sup> Albumin is necessary to maintain colloid osmotic pressure at the healing wound as well as to transport essential ions and amino acids to facilitate wound healing. Sage and Doyle<sup>3)</sup> reported that patients with albumin levels below 3.0 g/dL or total lymphocyte count below 1500 cells/mm<sup>3</sup> should be considered malnourished. Takahashi et al.<sup>16)</sup> reported that lymphopenia represents an immunodepressed state, indicating an increased susceptibility to infection, which may lead to the development of postoperative infections. Thus, induction of a hypoalbuminemic state, by aggressive dietary control, may be counterproductive in the early stages of wound healing.<sup>15)</sup>

Serum protein is the most important component that should be supplemented as a first step to improve the nutritional status of surgical patients preoperatively, when it is depleted. A protein-rich diet is absolutely necessary to improve nutritional status. Indeed, for emergency surgical patients with low serum albumin levels, parenteral administration of albumin protein and/or fresh blood is essential.

Quantifying the effect of nutrition on patient outcomes has usually been based on complication rates. Several authors have shown that depressed albumin and transferrin levels predict an increased incidence of complications and mortality in a variety of medical and hip fracture patients.<sup>1-7,10-14,16)</sup>

Postoperative high uptake of a protein-rich diet together with non-protein nutrition is recommended to enhance wound healing, and the efficiency with which administered protein is used for tissue repair depends on an adequate intake of calories generally from non-protein nutrients. In the postoperative period, an intake of as much as 0.5 g of nitrogen (1 g nitrogen = 6.25 g protein) and 4.5 cal/kg may be necessary to restore a positive nitrogen balance in nutritionally depleted patients.<sup>7-10)</sup>

To date, basic data on the prevalence of malnutrition in elderly surgical patients who undergo elective surgeries, total hip and knee arthroplasties, fracture fixation, and

infection patients have been limited in Korea. Nutritional status was quite good in the 'elective surgery patients' including arthroplasty, because the preoperative patient selection criteria were rather strict. All of these patients undergoing elective surgeries were ostensibly healthy with high levels of activity, while for patients undergoing non-elective surgery, including fractures, such strict selection criteria could not be applied considering the urgency of their injuries and needs.

This study on the nutritional status of surgical patients with various diseases and trauma in each decade clearly confirmed a gradual increase in the decadal incidence of malnutrition in the elderly beyond the 7th decade, particularly in the non-elective surgery group. Thus, it can provide overall basic preoperative nutritional data for surgical patients in Jeju.

This study has several limitations. The lack of several postoperative factors including complication rates

and the effects of (1) changes in albumin and lymphocyte count, (2) wound healing, (3) physical ability, and (4) hospital stays. Further studies are planned to address these issues. It is clear that a certain proportion of elderly patients have subclinical malnutrition.

In elderly patients, over age 60, regardless of physical ailments, there was some evidence indicating a gradual decline in nutritional and immune status in patients who underwent non-elective surgeries, such as fracture fixation. Also, approximately 50% of patients with orthopedic infections had some degree of malnutrition and immunosuppression regardless of age.

### CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

### REFERENCES

1. Dreblow DM, Anderson CF, Moxness K. Nutritional assessment of orthopedic patients. *Mayo Clin Proc.* 1981;56(1):51-4.
2. Jensen JE, Jensen TG, Smith TK, Johnston DA, Dudrick SJ. Nutrition in orthopaedic surgery. *J Bone Joint Surg Am.* 1982;64(9):1263-72.
3. Sage R, Doyle D. Surgical treatment of diabetic foot ulcers: a review of forty-eight cases. *J Foot Surg.* 1984;23(2):102-11.
4. Smith TK. Prevention of complications in orthopedic surgery secondary to nutritional depletion. *Clin Orthop Relat Res.* 1987;(222):91-7.
5. Sage RA. Diabetic ulcers: evaluation and management. *Clin Podiatr Med Surg.* 1987;4(2):383-93.
6. Dickhaut SC, DeLee JC, Page CP. Nutritional status: importance in predicting wound-healing after amputation. *J Bone Joint Surg Am.* 1984;66(1):71-5.
7. Harris WH, Sledge CB. Total hip and total knee replacement (1). *N Engl J Med.* 1990;323(11):725-31.
8. Patterson BM, Cornell CN, Carbone B, Levine B, Chapman D. Protein depletion and metabolic stress in elderly patients who have a fracture of the hip. *J Bone Joint Surg Am.* 1992;74(2):251-60.
9. Del Savio GC, Zelicof SB, Wexler LM, et al. Preoperative nutritional status and outcome of elective total hip replacement. *Clin Orthop Relat Res.* 1996;(326):153-61.
10. Gherini S, Vaughn BK, Lombardi AV Jr, Mallory TH. Delayed wound healing and nutritional deficiencies after total hip arthroplasty. *Clin Orthop Relat Res.* 1993;(293):188-95.
11. Nikolaus T, Bach M, Siezen S, Volkert D, Oster P, Schlierf G. Assessment of nutritional risk in the elderly. *Ann Nutr Metab.* 1995;39(6):340-5.
12. Lesourd B, Mazari L. Nutrition and immunity in the elderly. *Proc Nutr Soc.* 1999;58(3):685-95.
13. Koval KJ, Maurer SG, Su ET, Aharonoff GB, Zuckerman JD. The effects of nutritional status on outcome after hip fracture. *J Orthop Trauma.* 1999;13(3):164-9.
14. Parker MJ, Gurusamy K, Stoker M. Surgery in elderly patients. *Curr Orthop.* 2004;18(5):333-44.
15. Eneroth M, Olsson UB, Thorngren KG. Nutritional supplementation decreases hip fracture-related complications. *Clin Orthop Relat Res.* 2006;451:212-7.
16. Takahashi J, Shono Y, Hirabayashi H, et al. Usefulness of white blood cell differential for early diagnosis of surgical wound infection following spinal instrumentation surgery. *Spine (Phila Pa 1976).* 2006;31(9):1020-5.
17. Porrata LF, Ristow K, Colgan JP, et al. Peripheral blood lymphocyte/monocyte ratio at diagnosis and survival in classical Hodgkin's lymphoma. *Haematologica.* 2012;97(2):262-9.